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RESEARCH

The use of the gracilis flap in colorectal surgery: surgical technique, results, and review of the literature

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Abstract

Background The gracilis flap is rarely used in colorectal surgery and requires a multidisciplinary surgical team including plastic surgeons. There is a paucity of data on the outcome of the gracilis flap when performed by colorectal surgeons.

Methods A retrospective review was performed of all consecutive patients who underwent the gracilis flap at a single institution. Data collected included patient-related characteristics, indications for surgery, postoperative outcomes, and healing rates.

Results Eighteen patients underwent a total of 19 flaps. The median age was 60 years. Thirteen patients (72.2%) had prior radiation therapy. The most common indication for radiation was prostate carcinoma (38.9%) and rectal or anal carcinoma (33.3%). Indications for operation were complex fistulas in 14 patients (77.8%) or wound defect closure in four patients (22.2%). Six out of 14 patients (42.9%) had failed prior fistula repair. All patients had existing stoma or underwent stoma placement at the time of the gracilis flap. Median length of stay was 5 days. Post-operative complications occurred in three patients (16.7%), and the readmission rate was 11%. Flap failure was noted in three patients (16.6%). Both patients with rectourethral fistulas healed after additional intervention. During a median follow-up time of 24 months, 11 out of the 12 temporary stomas were closed, and one was converted to a permanent colostomy.

Conclusions The gracilis flap can be successfully used for complex pelvic fistulas and perineal wounds. This study demonstrates that a colorectal surgeon with interest and expertise in this technique can perform this operation with excellent outcomes.

Keywords Gracilis flap · Graciloplasty · Rectovaginal fistula · Rectourethral fistula · Perineal wounds

Introduction

Complex pelvic fistulas and perineal wounds can be challenging to treat. The most problematic rectourethral and rectovaginal fistulas often present with a history of radiation therapy and/or prior failed operations. Associated conditions include benign disorders such as inflammatory bowel disease, childbirth, trauma, iatrogenic injuries, and colorectal, urologic, or gynecologic malignancy [1–4]. Addressing such difficult situations often requires fecal diversion and selective urinary diversion in patients with urinary fistulas. Spontaneous healing may occur in a subset of patients with small fistulas, but patients with larger defects and/or compromised healing ability such as those with radiated, inflamed, or infected tissues often require flap repair for a successful outcome [5]. Several flap techniques have been previously described for the treatment of complex pelvic fistulas and/or closure of perineal defects. These operations include local small caliber flaps such as the endorectal and Martius (bulbocavernosus) flaps [6–8] or larger flaps including the omentum, rectus abdominus, gluteus, and gracilis [9–24]. The surgical principle for most of these flaps includes sliding a tissue, such as the endorectal advancement or gluteus flap, or rotating a muscle by disconnecting some of its attachments with preservation of its main neurovascular pedicle.

The gracilis rotational flap was introduced into the field of colorectal surgery several decades ago [13, 14]. Several studies have been previously published on the use of the gracilis flap in colorectal surgery, but most published

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literature has included a small number of patients from a few tertiary care academic surgical units. Furthermore, the harvest of the gracilis flap is often performed by a plastic reconstructive surgeon. This study describes the technical aspect of the gracilis flap and reports the experience of a colorectal surgeon with this operation.

Material and methods

This retrospective review was approved by the institutional review board. All patients who underwent the gracilis flap operation over a 10-year period were included. All operations, including the flap harvest, were performed by one colorectal surgeon (senior author) at Kaiser Permanente, Los Angeles, California. A urologist was involved in patients with urinary fistula. The outpatient and inpatient medical records were reviewed and data abstracted included patients' demographics, the indication for the gracilis flap, etiology of the condition, and associated comorbidities. Outcome measures included length of stay, postoperative complications, healing rate, and secondary interventions. No statistical analysis was required for this study.

Anatomy of the gracilis muscle

The gracilis muscle runs along the inner aspect of the thigh (Fig. 1). It is a long and relatively thin muscle which originates at the pubic bone, adjacent to the ischial ramus, with a distal tendinous attachment at the medial inferior aspect of the tibial condyle [25, 26]. Its dominant arterial blood supply derives proximally from the medial circumflex femoral artery (a branch of the deep femoral artery) with short perforators arising from the superficial femoral artery as it travels down the thigh [27–29]. The venous drainage mirrors the arterial supply. The proximal dominant neurovascular bundle is usually encountered within a 12-cm distance from the pubic tubercle in most adults. The gracilis muscle is innervated by the obturator nerve which arises from the lumbar plexus and runs through the obturator canal in the pelvis [25–29]. As a member of the adductor muscle group, the gracilis contributes to thigh flexion and adduction at the hip and leg flexion and internal rotation at the level of the knee.

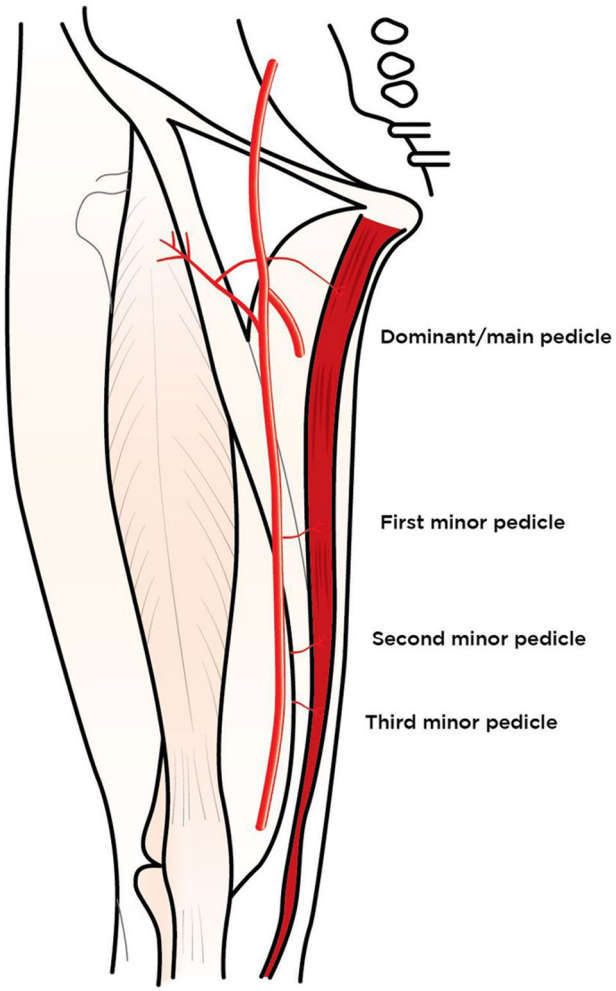

Fig. 1 Anatomy of the gracilis muscle

The gracilis muscle can be used as a flap with minimal impact on the function of the lower extremity. It can be used in the pelvic area as a rotational pedicled flap or in other parts of the body as a free microsurgical flap [30, 31]. The flap can be muscular or musculocutaneous. In colorectal surgery, the gracilis flap is usually used as a pedicled muscular flap.

Surgical technique for gracilis muscle harvest

The muscle harvest is performed in the lithotomy position with slight exaggeration in the external rotation of

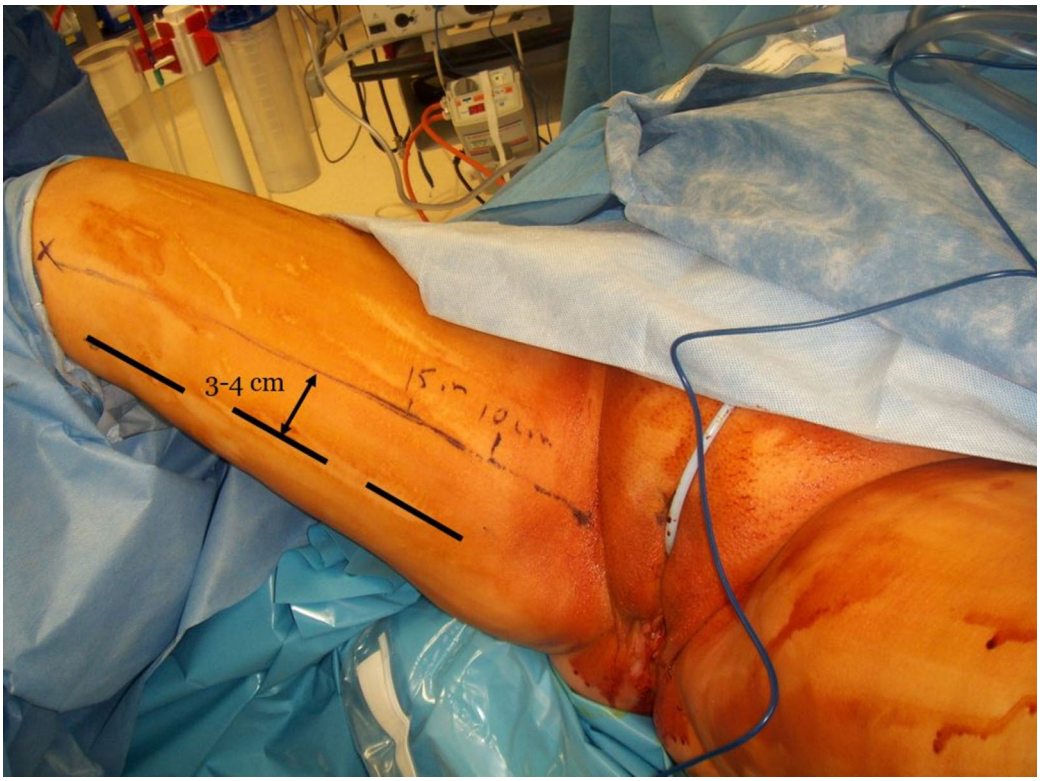

Fig. 2 Markings of the three incisions for the gracilis muscle (3 to 4 cm behind the anatomical line)

the hip to provide adequate exposure to the thigh (Fig. 2). The surgical field is prepped and draped to include the entire pelvis and both lower extremities to mid-leg level. In female patients, the vagina is prepped with Betadine. A urinary catheter is inserted. In males with rectourethral fistulas, selective cystoscopy with placement of ureteral catheters and/or a suprapubic tube is considered, as deemed appropriate by the urologist based on fistula characteristics, etiology, presence of urethral stricture, and quality of tissue. Intravenous antibiotics and deep venous thrombosis chemical prophylaxis are administered.

An anatomical line is drawn from the pubic bone to the medial aspect of the knee. The gracilis flap runs 3 to 4 cm posterior to that anatomical line. The anticipated location of the dominant neurovascular bundle is marked between 10 and 15 cm (Fig. 2). The gracilis muscle is accessed through three horizontal incisions about 3 to 4 cm posterior to the drawn anatomical line. Each incision length is between 4 and 6 cm, depending on the patient's size and body mass index. Dissection is carried through the skin and subcutaneous tissue until the fascia is encountered and incised. Once the fascia is incised, gentle blunt dissection is carried out with the finger circumferentially to isolate the gracilis, and a Penrose drain (CardinalHealth, Dublin, Ohio, USA) is wrapped around the muscle (Fig. 3). A confirmation that the proper muscle has been isolated is demonstrated by pulling on all three Penrose drains simultaneously and demonstrating the course of the gracilis (Fig. 3). Further confirmation is achieved by inspecting the distal long tendinous attachment. Through the most distal incision, the tendinous attachment at the knee is divided between clamps, and both ends are suture ligated to minimize the risk of bleeding (Fig. 4). Once the muscle is detached distally, the index finger of each hand is introduced through the mid and distal incisions, and blunt dissection is performed of the medial aspect of the muscle toward the subcutaneous tissue. Then the lateral aspect of the muscle is exposed with wound retractors, and the small

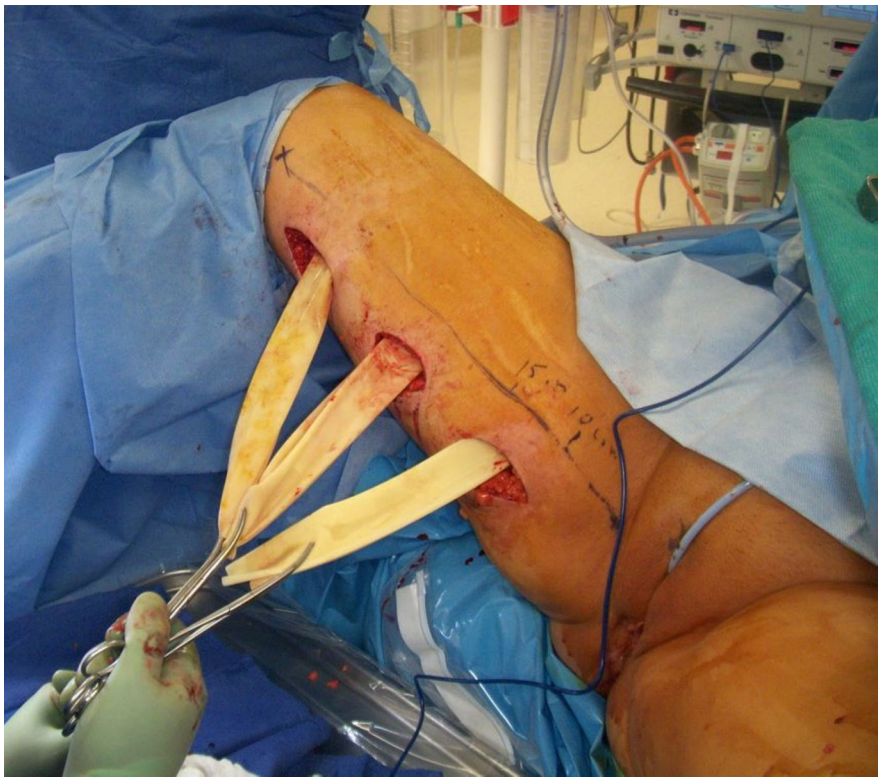

Fig. 3 Penrose drains wrapping around the identified gracilis

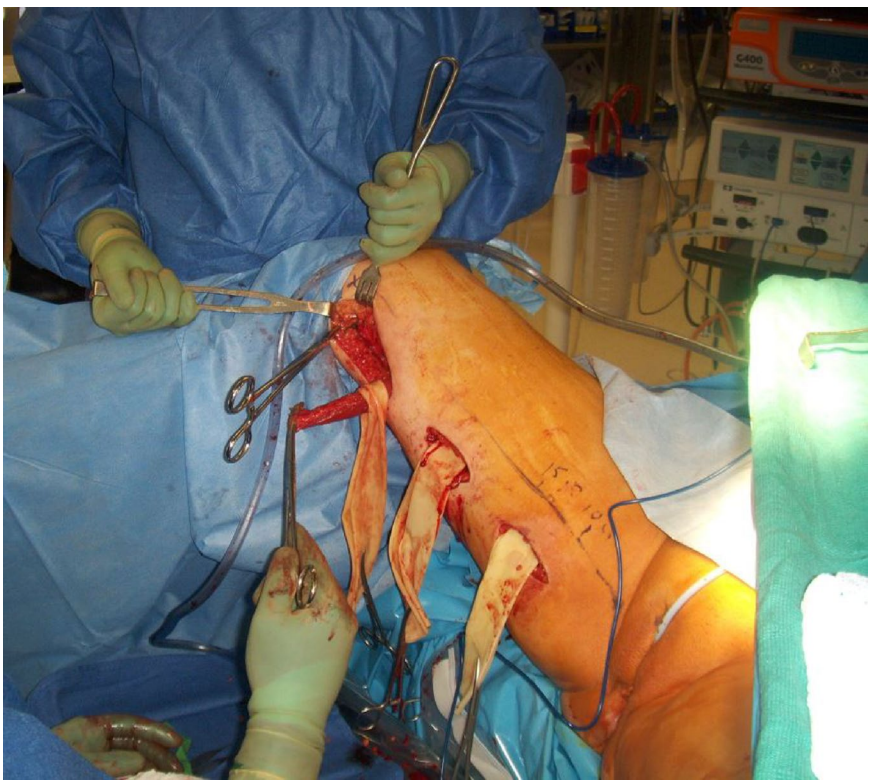

Fig. 4 Disconnection of the distal attachment of the gracilis at the knee level

Fig. 5 Delivery of the gracilis muscle through the proximal incision after blunt dissection and control of the perforators

perforators are identified and controlled with small metal clips. In most patients, three to four perforators are encountered. The same maneuver is repeated through the proximal and mid incisions, and the muscle is exteriorized with gentle care (Fig. 5). The dominant neurovascular bundle is identified through the proximal incision and preserved (Fig. 6). The muscle is rotated across the perineum externally to demonstrate adequate reach for tension-free repair of the fistula or wound coverage if the muscle is performed for closure of the perineal defect (Fig. 7). A subcutaneous pocket is created between the proximal incision and the perineum where a transverse incision is made, and the muscle is tunneled through with gentle traction (Figs. 8 and 9). The leg incisions are closed after draining the dissected space with a 19 French Blake drain (Ethicon, Inc, Cincinnati, Ohio, USA) which is exteriorized through the distal incision. The perineum is exposed using a Lone Star retractor (CooperSurgical, Inc, Trumbull, Connecticut, USA). For rectovaginal fistula, the rectal defect is closed primarily through a transperineal approach using absorbable sutures, following which, the gracilis interposition flap is anchored on top of the repair with the muscle covering the area of the fistula (Fig. 10). The perineal wound is closed externally, following which, the vagina is inspected, and a few additional sutures are placed to secure the flap to the vaginal wall. In men with rectourethral fistula, the same steps are repeated with the following modifications (Fig. 11). After tunneling the muscle to the perineum, the patient is repositioned in the prone position to repair the urethra and interpose the gracilis muscle. Following that step, the perineal wound is closed. Through the transanal approach, additional sutures are placed to anchor the flap to the rectal wall. Of note, when interposing the gracilis muscle for both rectovaginal and rectourethral coverage, the muscle should cover at least a 2-cm area cephalad to the proximal aspect of the fistula to ensure good interposition. All wounds are covered with antibiotic ointment, and the leg is wrapped to minimize the extent of swelling. The drain is usually removed between 3 and 5 days. Oral antibiotics are administered for 10 days in most patients.

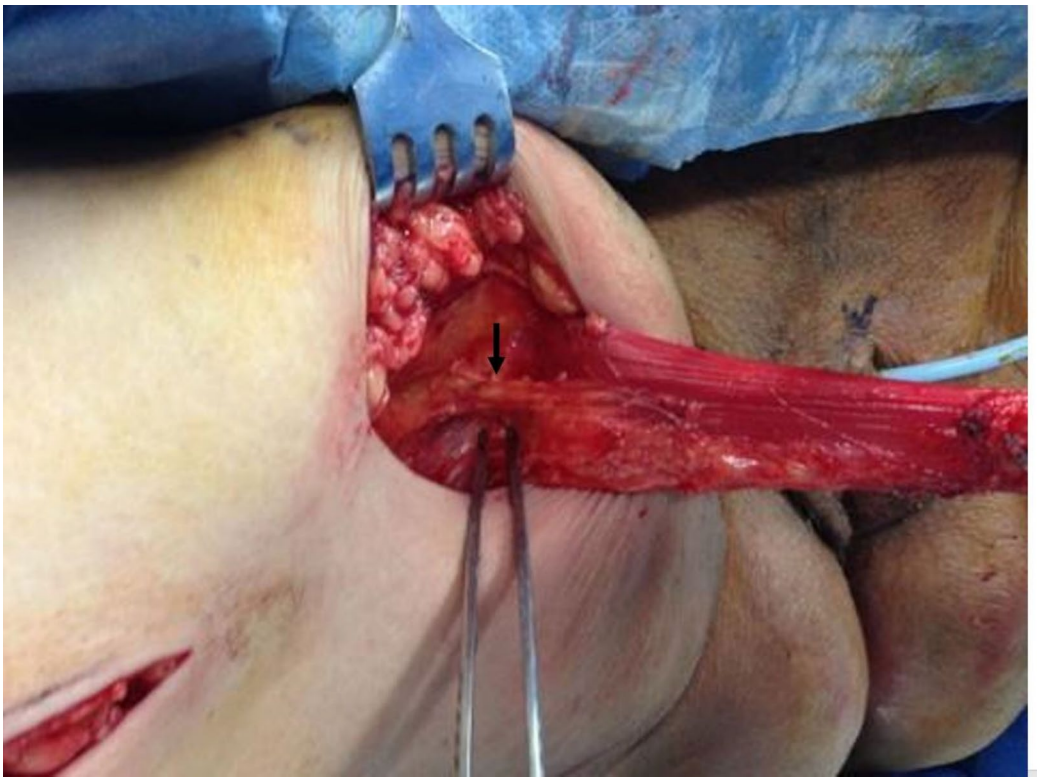

Fig. 6 Identification and preservation of the dominant neurovascular pedicle

Fig. 7 Demonstration of adequate mobilization of the gracilis flap with good coverage across the perineum

Fig. 8 Careful rotation of the gracilis muscle toward the perineum by grabbing the sutured tendinous end and pulling it with a clamp through the perineal incision

Fig. 9 Closure of the leg incisions over a drain placed through the distal incision

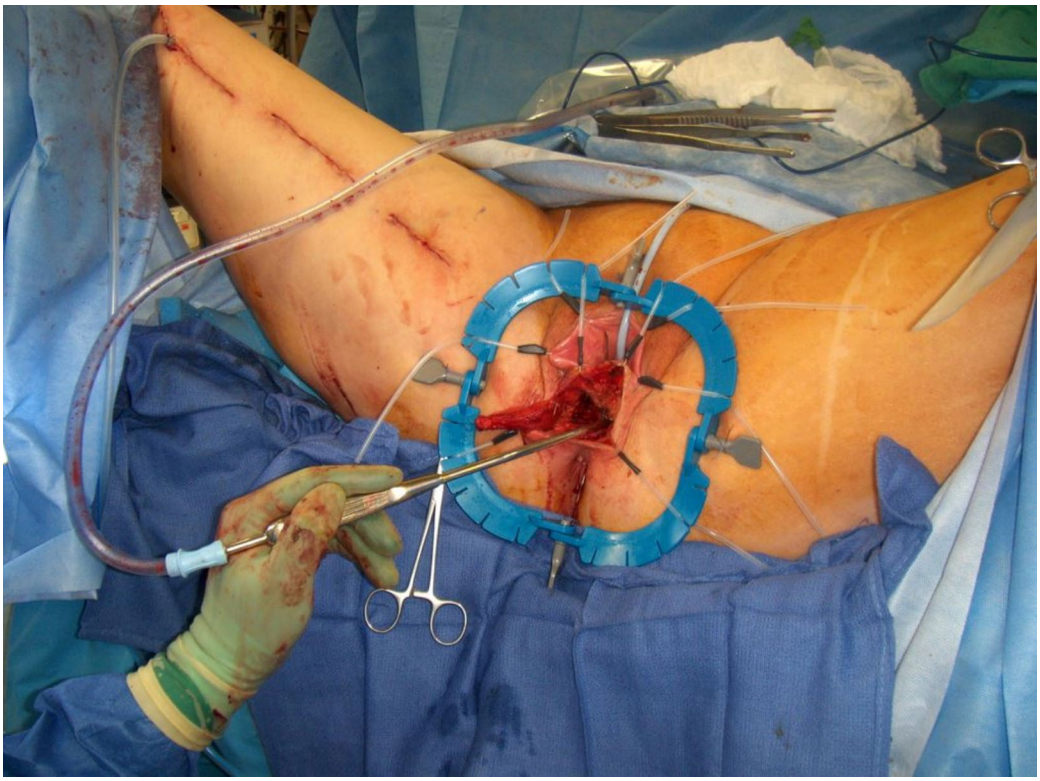

Fig. 10 Transperineal dissection for repair of the fistula with interposition of the gracilis with LoneStar retractor exposure

Results

Eighteen patients underwent a total of 19 gracilis flaps over a 10-year period. Table 1 summarizes the patients' characteristics. The median age was 60 years. Prior radiation therapy was noted in 72.2% of the patients. The most common malignancy type was prostate cancer. Six out of 14 patients with complex fistulas (42.9%) had undergone prior fistula repair.

Table 2 represents the indication for the gracilis flap. Transperineal fistula repair was performed in 14 patients (77.8%), and in four patients (22.2%), the gracilis flap was used to close a perineal defect. All patients had a diverting stoma (either established previously or placed at time of the gracilis flap). The stoma intent was temporary in 12 patients (66.7%) and permanent in six patients (33.3%).

Table 3 reports the outcome of the 18 patients. Median length of stay was 5 days. Readmission rate was 11% (one patient with deep venous thrombosis of the lower extremity and one patient for reinsertion of urinary catheter). Postoperative complications occurred in three patients (16.7%). Flap failure was noted in three patients (16.7%)—two rectourethral and one rectovaginal fistula. Both patients with rectourethral fistula healed after secondary interventions—one with repeated gracilis flap and one following pelvic exenteration for recurrent malignancy. The patient with persistent rectovaginal fistula elected to live with a permanent stoma. During a median follow-up of 24 months, 11 out of the 12 temporary stomas were closed (91.7%), and one patient was converted from a temporary ileostomy to a permanent colostomy.

Fig. 11 Final closure of the perineal wound after interposition of the gracilis muscle and anchoring it to the rectal and vaginal walls

Discussion

Complex pelvic fistulas involving the vagina in females and the urinary tract in males can be challenging to manage. Often, the surgeon is faced with findings such as large tissue defects, prior failed repair, fibrotic poorly vascularized tissue, and radiation-related tissue damage. This study aimed to review a single colorectal surgeon's experience with the gracilis flap, an uncommon yet important operation in some patients with challenging colorectal conditions. The majority of cases were performed for complex rectovaginal or rectourethral fistulas in patients with a prior history of malignancy and radiation therapy. Nearly half of the patients had prior failed repairs. All

Table 1 Patients' characteristics

	N = 18
Gender (male/female)	8/10 (44.4%/55.6%)
Median age (range) years	60 (25–72)
Mean body mass index (range) kg/m^2	28 (19–38.1)
Prior radiation therapy	13 (72.2%)
External beam	10
Brachytherapy	3
Malignancy	14 (77.8%)
Prostate cancer	7
Rectal cancer	3
Anal cancer	3
Bladder cancer	1
Prior fistula repair	6 (42.9%)

Table 2 Indications for the 18 gracilis flaps

Indications	
Fistula repair	14 (77.8%)
Rectovaginal	7
Rectourethral	6
Urethracutaneous	1
Perineal wound coverage	4 (22.2%)
Post abdominoperineal resection	3
Pelvic exenteration	1

Table 3 Outcome of the 18 gracilis flaps

Outcome	
Median length of stay (range) days	5 (3–20)
Readmission	2 (11%)
Postoperative complications	3 (16.7%)
Upper extremity deep venous thrombosis	1
Lower extremity deep venous thrombosis	1
Wound infection	1
Primary flap success	15 (83.3%)
Additional surgical intervention	3 (16.7%)
Second gracilis flap	1
Pelvic exenteration	1
Conversion from ileostomy to colostomy	1
Closure of temporary stoma	11/12 (91.7%)
Median follow-up time (range) months	24 (1–81)

operations were performed without the involvement of a reconstructive plastic surgeon, with a high success rate. Furthermore, the complication and readmission rates were low. Reversal of temporary fecal diversion was achieved in most patients.

The gracilis flap use in colorectal and gynecologic surgery was initially reported in a few small retrospective studies in the latter part of the twentieth century [32–35, 43]. In the last two decades, there has been increasing interest in the use of this flap in perineal wound closure [1, 16, 17, 19, 39, 43, 50, 51, 57, 58, 62–64, 66, 69, 71, 73], repair of complex pelvic fistulas [18, 22–24, 36–38, 41, 42, 44, 46–49, 52, 55, 56, 65, 67, 68, 70, 72, 74, 75], Crohn's disease [20, 21, 45], and incontinence [53]. Most of the data available on this flap is derived from small retrospective studies and, in some instances, several reports from the same institution [21, 22, 24, 36–38, 43, 54, 65, 68, 74]. Furthermore, the technical harvest of the gracilis muscle is usually performed by a multidisciplinary team including colorectal surgeons, urologists, gynecologists, and reconstructive plastic surgeons. There is a paucity of data on the gracilis flap harvest performed by a colorectal surgeon, as it is not traditionally included in the training of the specialty, and most of the initial technical data on this muscle was derived from the reconstructive plastic surgeons' experience [25–31].

In this article, a review of the anatomy and function of the gracilis muscle was provided along with a detailed description for the step-by-step harvest of the gracilis flap. Results of the flap performed by one colorectal surgeon were highlighted, demonstrating a high success rate with minimal morbidity and reversal of temporary stoma in the majority of the patients. This study adds to the scientific data available to date. A literature review of the most relevant studies on the use of the gracilis flap in 1121 patients with pelvic disorders is presented in Tables 4, 5, 6, and 7 [13, 14, 16, 18, 21, 23, 24, 32–36, 40–75]. The mean age of patients in the reviewed studies was 46.6 years, with a slight predominance of females. The most common etiology of the fistula was malignancy (prostate, rectum, anus, gynecologic), with over 1/3 of the patients having a prior history of radiation therapy. In most cases of malignancy, the indication for the gracilis flap was to treat a complication arising from the treatment (i.e., radiation therapy or surgical intervention). Less common etiologies included inflammatory bowel disease (Crohn's disease and ulcerative colitis), trauma (motor vehicle accident or blast injury), or prior obstetrical injury (Table 4). Rare etiologies not represented in the table included congenital disorders and benign cryptoglandular anal fistulas. Approximately 2/3 of the patients had a prior failed repair. The most common indications for the gracilis flap reconstruction were complex fistulas (rectal, vaginal, urinary) and perineal wound/sinus closure (Table 5). Anal sphincter reconstruction for incontinence was an uncommon indication for the gracilis flap. The types of rectal fistulas included rectovaginal, rectourethral, and rectovesical. Additional variations of vaginal fistulas included anovaginal and ileal pouch vaginal. Urethroperineal fistula was uncommon. Other types included transsphincteric anal fistulas.

Table 6 represents short- and long-term outcomes of the gracilis flap. The mean length of stay was over 11 days, with a range between 4 and 22.7 days. Postoperative complications occurred in about 1/3 of the patients. Readmission following the gracilis flap operation occurred in nearly one in every five patients. Overall healing was achieved in 82.9% of the patients. The rectourethral fistula healing rate was higher compared to the rectovaginal fistula (92.5% vs. 74.5%). The majority of patients who underwent the gracilis flap had a diverting stoma (Table 7). In over ½ of the patients, the stoma was constructed prior to the gracilis flap operation, while in slightly over 1/3 of the patients, it was placed at the time of the gracilis operation. In nearly ½ of the patients, the stoma was permanent.

Table 4 Patient characteristics in various studies in the literature

Author	Country	Year	*N*	Gender (M/F)	Mean age (Years)	Prior radiation (%)	Inflammatory bowel disease (%)	Malignancy (%)	Trauma (%)	Obstetric injury (%)	Prior operation (%)
Wheeless (32)	USA	1979	5	0/5	62	60	0	100	0	0	0
Woods (13)	USA	1983	14	5/9	-	0	64.3	14.3	0	0	100
Ryan (14)	USA	1984	15	8/7	35	0	100	0	0	0	100
Burke (33)	USA	1995	17	0/17	55	47	0	100	0	0	0
Solomon (34)	Australia	1996	5	1/4	48.6	40	60	40	0	0	100
Christiansen (35)	Denmark	1998	13	3/10	48	0	0	0	7.7	46.2	100
Rius (21)	USA	2000	7	2/5	35	0	100	0	0	0	71.4
Zmora (36)	USA	2003	11	11/0	62	54.5	0	100	0	0	45.5
Menon (16)	UK	2005	7	3/4	-	0	83.7	0	0	0	76.4
Vermaas (18)	Netherlands	2005	18	13/5	61*	100	0	100	0	0	100
Zmora (37)	USA	2006	9	3/6	47	33.3	33.3	33.3	0	0	77.8
Wexner (38)	USA	2008	53	36/17	58	32.1	18.9	69.8	0	0	64.1
Fürst (23)	Germany	2008	12	0/12	37	0	100	0	0	0	100
Ducic (39)	USA	2008	19	-	66	52.6	-	47.4	-	-	100
Ghoniem (24)	USA	2008	25	25/0	68	60	0	100	0	0	100
Gupta (40)	India	2008	15	15/0	38	0	0	0	20	0	20
Lefevre (41)	France	2009	8	0/8	39	0	62.5	0	0	12.5	100
Ulrich (42)	Germany	2009	35	26/9	58	47.8	20.4	57.1	0	0	71.4
Shibata (43)	USA	2009	16	16/0	61	100	0	100	0	0	0
Nassar (44)	Egypt	2011	11	0/11	49	36.4	0	100	0	0	100
Maeda (45)	Denmark	2011	18	8/10	33	0	100	0	0	0	27.7
Chen (46)	China	2013	19	8/11	47	26.3	0	47.4	0	15.8	100
Troja (47)	Germany	2013	10	0/10	46.6	70	10	70	0	10	100
Corte (48)	France	2015	32	0/32	43	5	43.8	12.5	0	9.4	100
Tran (49)	Canada	2015	7	7/0	62	100	0	100	0	0	100
Kaartinen (50)	Finland	2015	12	0/12	69	100	0	100	0	0	33.3
Chong (51)	USA	2015	16	11/5	62	100	0	100	0	0	0
Raup (52)	USA	2015	27	27/0	60	74.1	0	74.1	0	0	100
Kalra (53)	India	2016	18	15/3	-	0	0	0	83.3	0	100
Singh (54)	USA	2016	40	22/18	56.8	70	15	85	0	0	0
Park (55)	S. Korea	2017	11	0/11	46	63.6	27.3	72.7	0	0	100
Munoz-Duyos (56)	Spain	2017	9	9/0	67	0	0	100	0	0	100
Leeds (57)	USA	2017	5	3/2	60	60	0	80	0	0	100
Sieffert (58)	USA	2017	6	4/2	63	100	0	100	0	0	0
Rottoli (59)	Italy	2018	21	0/21	45*	0	38.1	0	0	14.3	100

Table 4 (continued)

Author	Country	Year	*N*	Gender (M/F)	Mean age (Years)	Prior radiation (%)	Inflammatory bowel disease (%)	Malignancy (%)	Trauma (%)	Obstetric injury (%)	Prior operation (%)
Kersting (60)	Germany	2019	19	0/19	48	5.3	31.6	31.6	0	0	100
Korsun (61)	Germany	2019	32	2/30	39	0	100	0	0	0	100
Kiiski (62)	Finland	2019	39	0/39	59	76	0	100	0	0	0
Coelho (63)	UK	2019	25	9/16	62	84	0	84	0	0	100
Weinstein (64)	USA	2020	6	2/4	63	66.7	0	83.3	0	0	-
Gilsshtein (65)	USA	2020	9	5/4	55	44.4	22.2	44.4	0	0	100
Sasaki (66)	Japan	2021	7	7/0	62	42.9	0	100	0	0	0
Grott (67)	Germany	2021	46	12/34	54	41.3	28.2	41.3	0	17.4	100
Yellinek (68)	USA	2021	119	60/59	56*	32	15.1	32**	5	0	100
Zhang (69)	China	2022	31	0/31	54	0	0	100	0	0	0
Sbizzera (70)	France	2022	21	21/0	66*	14	0	100	0	0	66.7
DeLozier (71)	USA	2023	45	28/17	60*	68.9	28.9	68.9	0	0	-
Schoene (72)	Germany	2023	60	44/16	50	28.3	0	28.3	0	13.3	98.3
Jenkins (73)	UK	2023	50	26/24	62*	84	0	100	0	0	0
Strassmann (74)	USA	2023	6	0/6	34	0	0	0	0	100	100
Hull (75)	USA	2023	22	0/22	43*	9.1	18.1	9.1	4.5	13.6	100
Muharrem	USA	2025	18	8/10	60*	77.2	0	77.8	0	0	42.9
			1121	505/597	46.6	39.7	14.7	51.5	2.3	2.8	66.9

*Median age (years)

**At least 38 patients (32%) had cancer-related causes due to radiation therapy, with additional overlap from pelvic surgeries likely contributing to the total

Table 5 Indications for the gracilis flap in various studies in the literature

Author	Country	Year	*N*	Rectourethral/urinary fistula (%)	Rectovaginal fistula (%)	Perineal wound (%)	Anal sphincter (%)	Others (%)
Wheeless (32)	USA	1979	5	0	0	100	0	0
Woods (13)	USA	1983	14	0	0	100	0	0
Ryan (14)	USA	1984	15	0	0	100	0	0
Burke (33)	USA	1995	17	0	0	100	0	0
Solomon (34)	Australia	1996	5	0	0	100	0	0
Christiansen (35)	Denmark	1998	13	0	0	0	100	0
Rius (21)	USA	2000	7	14.3	29	42.9	0	13.8
Zmora (36)	USA	2003	11	100	0	0	0	0
Menon (16)	UK	2005	7	0	0	100	0	0
Vermaas (18)	Netherlands	2005	18	0	0	100	0	0
Zmora (37)	USA	2006	9	33.3	56	0	0	10.7
Wexner (38)	USA	2008	53	67.9	28	0	0	4.1
Fürst (23)	Germany	2008	12	0	100	0	0	0
Ducic (39)	USA	2008	19	0	0	100	0	0
Ghoniem (24)	USA	2008	25	100	0	0	0	0
Gupta (40)	India	2008	15	100	0	0	0	0
Lefevre (41)	France	2009	8	0	100	0	0	0
Ulrich (42)	Germany	2009	35	74.3	25.7	0	0	0
Shibata (43)	USA	2009	16	0	0	100	0	0
Nassar (44)	Egypt	2011	11	0	100	0	0	0
Maeda (45)	Denmark	2011	18	0	11.1	0	0	88.9
Chen (46)	China	2013	19	42.1	57.9	0	0	0
Troja (47)	Germany	2013	10	0	100	0	0	0
Corte (48)	France	2015	32	0	100	0	0	0
Tran (49)	Canada	2015	7	100	0	0	0	0
Kaartinen (50)	Finland	2015	12	0	0	100	0	0
Chong (51)	USA	2015	16	0	0	100	0	0
Raup (52)	USA	2015	27	100	0	0	0	0
Kalra (53)	India	2016	18	0	0	0	100	0
Singh (54)	USA	2016	40	0	0	100	0	0
Park (55)	S. Korea	2017	11	0	100	0	0	0
Munoz-Duyos (56)	Spain	2017	9	100	0	0	0	0
Leeds (57)	USA	2017	5	0	0	100	0	0
Sieffert (58)	USA	2017	6	0	0	100	0	0
Rottoli (59)	Italy	2018	21	0	100	0	0	0
Kersting (60)	Germany	2019	19	0	100	0	0	0
Korsun (61)	Germany	2019	32	3.1	72	0	0	24.9
Kiiski (62)	Finland	2019	39	0	0	100	0	0
Coelho (63)	UK	2019	25	0	0	100	0	0
Weinstein (64)	USA	2020	6	0	0	100	0	0
Gilshtein (65)	USA	2020	9	55.6	22	0	0	22.4
Sasaki (66)	Japan	2021	7	0	0	100	0	0
Grott (67)	Germany	2021	46	4.3	62	0	0	33.7
Yellinek (68)	USA	2021	119	48.7	41	0	0	10.3
Zhang (69)	China	2022	31	0	0	100	0	0
Sbizzera (70)	France	2022	21	100	0	0	0	0
DeLozier (71)	USA	2023	45	0	0	100	0	0
Schoene (72)	Germany	2023	61	5	57	0	0	38
Jenkins (73)	UK	2023	50	0	0	100	0	0
Strassmann (74)	USA	2023	6	0	100	0	0	0
Hull (75)	USA	2023	22	0	100	0	0	0
Muharrem	USA	2024	18	38.9	38.9	22.2	0	0
			1121	265/1121 (23.63)	340/1121 (30.3)	405/1121 (36.1)	31/1121 (2.76)	80/1121 (7.1)

Table 6 Outcome of the gracilis flap in various studies in the literature

Author	Country	Year	*N*	Mean length of stay (days)	Complication rates (%)	Readmission rate (%)	Overall healing rate (%)	Rectourethral fistula healing rate (%)	Rectovaginal fistula healing rate (%)	Mean length of follow-up (months)
Wheeless (32)	USA	1979	5	-	60	0	100	-	-	-
Woods (13)	USA	1983	14	8*	14.3	-	92.8	-	-	-
Ryan (14)	USA	1984	15	-	80	60	93	-	-	60
Burke (33)	USA	1995	17	-	-	-	47	-	-	25*
Solomon (34)	Australia	1996	5	17.4	40	20	100	-	-	25
Christiansen (35)	Denmark	1998	13	-	69	69	45	-	-	-
Rius (21)	USA	2000	7	-	28.6	28.6	71.4	100	50	17.8
Zmora (36)	USA	2003	11	5.3	33	18.2	100	100	-	18
Menon (16)	UK	2005	7	-	57.1	14.3	57.1	-	-	24**
Vermaas (18)	Netherlands	2005	18	9*	89	-	87.5	-	-	22**
Zmora (37)	USA	2006	9	5.3	33.3	-	77.8	100	80	26
Wexner (38)	USA	2008	53	-	47	-	69–8	78	52.9	26**
Fürst (23)	Germany	2008	12	-	8.3	-	91.7	-	91.7	40.8
Ducic (39)	USA	2008	19	-	5.3	-	100	-	-	-
Ghoniem (24)	USA	2008	25	5.3*	24	8	100	100	-	28
Gupta (40)	India	2008	15	-	20	6.7	100	100	-	24
Lefevre (41)	France	2009	8	10	37.5	-	88	-	88	28
Ulrich (42)	Germany	2009	35	-	8.6	-	94.3	96,2	77.8	28
Shibata (43)	USA	2009	16	-	37.5	12.5	87.5	-	-	-
Nassar (44)	Egypt	2011	11	-	36.4	-	100	-	100	34
Maeda (45)	Denmark	2011	18	-	44.4	33.3	61.1	-	50	64**
Chen (46)	China	2013	19	21*	21.1	-	94.7	100	90.9	17**
Troja (47)	Germany	2013	10	-	20	-	60	-	60	46.6
Corte (48)	France	2015	32	-	-	-	50	-	50	33.1**
Tran (49)	Canada	2015	7	3.6	28.6	0	100	100	-	11.4
Kaartinen (50)	Finland	2015	12	-	33	0	100	100	-	-
Chong (51)	USA	2015	16	13	43.8	6.3	100	-	-	-
Raup (52)	USA	2015	27	-	70.4	25.9	70.4	75	-	28.7
Kalra (53)	India	2016	18	8	38.9	-	100	-	-	-
Singh (54)	USA	2016	40	7.9	52.5	-	100	-	-	24
Park (55)	S. Korea	2017	11	-	9.1	-	72.7	-	72.7	46.4
Munoz-Duyos (56)	Spain	2017	9	8	22.2	-	100	100	-	54
Leeds (57)	USA	2017	5	-	40	20	100	100	-	15.5
Sieffert (58)	USA	2017	6	11.5	33.3	16.7	100	-	-	15.5
Rottoli (59)	Italy	2018	21	6.6*	14.3	-	71.4	-	71.4	66.1**

Table 6 (continued)

Author	Country	Year	*N*	Mean length of stay (days)	Complication rates (%)	Readmission rate (%)	Overall healing rate (%)	Rectourethral fistula healing rate (%)	Rectovaginal fistula healing rate (%)	Mean length of follow-up (months)
Kersting (60)	Germany	2019	19	11	26.3	-	73.7	-	73.7	23
Korsun (61)	Germany	2019	32	-	21.9	-	71	100	71	47
Kiiski (62)	Finland	2019	39	22.7	71.8	26.6	69.2	-	-	35.1
Coelho (63)	UK	2019	25	14	28	52	72	-	-	19
Weinstein (64)	USA	2020	6	11*	33	16.7	100	-	-	-
Gilshtein (65)	USA	2020	9	-	11	0	55	80	50	-
Sasaki (66)	Japan	2021	7	18	42.9	0	100	-	-	-
Grott (67)	Germany	2021	46	16	23.9	-	74	-	74	73.4
Yellinek (68)	USA	2021	119	6.5	37	-	92	-	90.2	16.3
Zhang (69)	China	2022	31	18	25.8	-	96.8	-	-	-
Sbizzera (70)	France	2022	21	4*	43	5	95	95	-	27
DeLozier (71)	USA	2023	45	8*	55.6	8.9	100	-	-	-
Schoene (72)	Germany	2023	60	-	25	-	65	100	87.5	35.9
Jenkins (73)	UK	2023	50	11*	-	16	86	-	-	4**
Strassmann (74)	USA	2023	6	8*	50	-	100	-	100	9.8
Hull (75)	USA	2023	22	8*	32	-	59	-	59	22**
Muharrem	USA	2025	18	5*	16.7	11	94,4	100	85.7	24**
			1121	11.2	32.5	18.3	82.9	198/214 (92.5)	254/341 (74.5)	16.6

*Median length of stay (days)

**Median follow-up (months)

Table 7 Stoma data from various studies in the literature

Author	Country	Year	*N*	Patients with stoma	Stoma before gracilis flap	Stoma during gracilis flap	Stoma closure	Permanent stoma
Wheeless (32)	USA	1979	5	1	1	0	0	1
Woods (13)	USA	1983	14	12	12	0	0	12
Ryan (14)	USA	1984	15	15	15	0	0	15
Burke (33)	USA	1995	17	-	-	-	-	-
Solomon (34)	Australia	1996	5	3	3	0	0	3
Christiansen (35)	Denmark	1998	13	13	13	0	13	0
Rius (21)	USA	2000	7	4	4	0	2	2
Zmora (36)	USA	2003	11	11	0	11	11	0
Menon (16)	UK	2005	7	7	7	0	0	7
Vermaas (18)	Netherlands	2005	18	18	18	0	0	18
Zmora (37)	USA	2006	9	9	9	0	7	2
Wexner (38)	USA	2008	53	53	-	-	42	11
Fürst (23)	Germany	2008	12	12	0	12	11	1
Ducic (39)	USA	2008	19	-	-	-	-	-
Ghoniem (24)	USA	2008	25	25*	-	-	21	4**
Gupta (40)	India	2008	15	15	15	0	15	0
Lefevre (41)	France	2009	8	8	7	1	7***	1
Ulrich (42)	Germany	2009	35	35	0	35	35	0
Shibata (43)	USA	2009	16	16	0	16	0	16
Nassar (44)	Egypt	2011	11	11	0	11	11	0
Maeda (45)	Denmark	2011	18	18	5	13	0	18
Chen (46)	China	2013	19	15	15	0	15	0
Troja (47)	Germany	2013	10	10	10	0	10	0
Corte (48)	France	2015	32	31	31	0	-	-
Tran (49)	Canada	2015	7	7	7	0	4	3
Kaartinen (50)	Finland	2015	7	1	1	0	-	-
Chong (51)	USA	2015	16	16	-	-	0	16
Raup (52)	USA	2015	27	27	27	0	27	0
Kalra (53)	India	2016	18	0	0	0	0	0
Singh (54)	USA	2016	40	40	40	0	0	40
Park (55)	S. Korea	2017	11	7	0	7	7	0
Munoz-Duyos (56)	Spain	2017	9	7	7	0	7	0
Leeds (57)	USA	2017	5	5	0	5	0	5
Sieffert (58)	USA	2017	6	6	0	6	0	6
Rottoli (59)	Italy	2018	21	21	21	0	21	0
Kersting (60)	Germany	2019	19	19	15	4	19	0
Korsun (61)	Germany	2019	32	31	0	31	18	13
Kiiski (62)	Finland	2019	39	25	0	25	0	25
Coelho (63)	UK	2019	25	25	25	0	0	25
Weinstein (64)	USA	2020	6	6	6	0	0	6
Gilsshtein (65)	USA	2020	9	9	9	0	7	2
Sasaki (66)	Japan	2021	7	7	7	0	0	7
Grott (67)	Germany	2021	46	44	44	0	14****	29
Yellinek (68)	USA	2021	119	119	-	-	103*****	0
Zhang (69)	China	2022	31	4	0	4	4	0
Sbizzera (70)	France	2022	21	12	12	0	10	2
DeLozier (71)	USA	2023	45	45	45	0	0	45
Schoene (72)	Germany	2023	60	60	0	60	36	24

Table 7 (continued)

Author	Country	Year	*N*	Patients with stoma	Stoma before gracilis flap	Stoma during gracilis flap	Stoma closure	Permanent stoma
Jenkins (73)	UK	2023	50	50	-	-	0	50
Strassmann (74)	USA	2023	6	6	0	6	6	0
Hull (75)	USA	2023	22	22	21	1	14	8
Muharrem	USA	2025	18	18	-	-	11	7
			1121	981/1085 (90.4%)	452/700 (64.5%)	248/700 (35.4%)	508/949 (53.5%)	424/949 (44.6%)

*All patients had diversion if they did not have it before

**1 stoma is not closed because of anal incontinence

***1 patient refused closure due to concerns about potential recurrence of Crohn's disease

****1 patient lost follow-up

*****16 patients lost to follow-up

Conclusions

A subgroup of patients with complex anorectal fistulas and/or perineal wounds requires the use of a well-vascularized non-fibrotic tissue for a successful surgical outcome. Several flap techniques have been described, including sliding or rotational flaps. The gracilis muscle is a great option for a select group of patients, and it can be used as a muscular or musculocutaneous rotational flap. This study illustrates that the use of such flaps by a colorectal surgeon is associated with a high healing rate, an acceptable length of stay, and low complication and readmission rates.

Author contribution Authors contributions: M.O Summary of data, literature review, initial manuscript drafting A:T.T. Data collection and analysis M.A. A. Conception/design, data analysis/interpretation, revision and final approval of manuscript.

Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate This retrospective review was approved by the institutional review board.

Competing interests The authors declare no competing interests.

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